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Model for Monitoring Pricing Mechanism By Among Beta Coefficient OEE and MC

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Abstract: *Businesses producing in small quantities and high diversityhaveusedMCpricing because of market competition. To reduce the risk to profitwith availability heuristic, dependentvariables fusion can be adopted by using MCpricingto correspond to the overall equipment effectiveness (OEE). This approach reflects the dynamic game in a timely independent variable mannerbased on rolled throughput yield measures. The OEE comprises indexes as quality(Q), performance(P), and availability(A). These three indexes reconcile theMC in optimization of marginal revenue (MR). In practice, shop floor management measures key indexes of final yield and utilization; the objective is to eliminatemisapplied andstatic pricingproblem by using beta coefficient.The correspondenceof among the beta coefficient, OEE andMCis deduced and verified in this paper, the model uses Lingo to calculate the quotient as the beta coefficient found by OEE dividing indexesofP*A*Q. This realizes dynamic examination and monitor of cost difference under individual MC. One case study is employed to explain the MC pricing strategy in industry.*

Keywords: *Beta coefficient, OEE, MC, MR,Throughput yield*

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I. Introduction

The OEE is a powerful metric used to improve the effective use of resources, by machine(Fast, 2018).Whenmachines running at rated speed,the production capacity iswell constant, the average cost (AC) curve of the economics of scale is higher than the marginal cost (MC) curve(Hsu, 2013), and this is the pricing mechanism of the average business in industry, as illustrated in Fig. 1(Margetts, 2017). Usually, using the AC for price setting and using the fixed cost, variable cost, and price floor to determine the pricing mechanism result in distorted cost accuracy, leaving a gap in cost pricing, this does not well profit for businesses (Noreen and Burgstahler, 1998).

In the manufacturing industry, the most crucial index offering timely reflective output information during production is effectiveness. The OEE is the product of three indexesbased on throughput yield mechanism, namely personnel performance and equipment availability of internal variables, and product quality of external variable; these indexes are also crucial factors for measuring businesses management.Lots of studies have discussed the relevant technical aspects and measurement methods between of throughput yield and OEE. However, few studies have discussed mathematical models of MC that can be used to calculate beta coefficient. Using mathematical model of beta coefficient to update new pricing mechanism of MC demonstrates the unique feature of a study. MC will be the pricing mechanism in markets where the quantity and diversity of products are small. The process yield measures are displayed in Table 1(MBA Skool, 2019). and the beta coefficient is the product of OEE dividing by quality x performance x availability after collection ofquality , time, and speedavailable.Models are used established based on theories and experiment. This provides the manufacturing industry with an optimized beta coefficient competitive strategy for effective applyingpricing mechanism.

Fig 1: Relationship between SAC and LAC with SMC and LMC

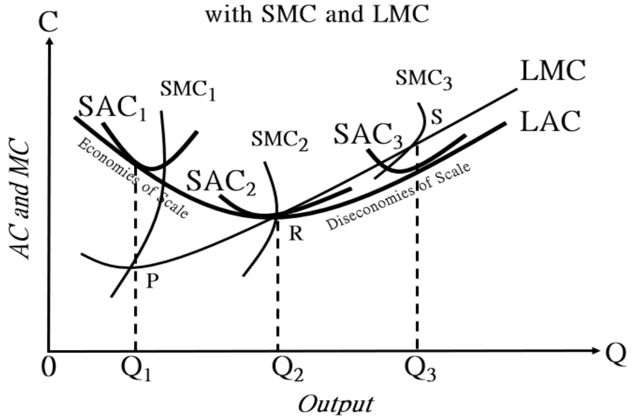

Table 1: Process Yield Measures

First Time Yield	Final Yield
Throughput Yield	Rolled Throughput Yield

II. Literature Review

When product capacity is constant, because of the law of diminishing marginal productivity, increased production capacity and time cause a shift in dynamic volatility. The SMC curve is lower than the average SAC curve; this characteristic has become the pricing mechanism of the average business(Hsu, 2013). If production capacity is increased, AC pricing is superior to marginal opportunity cost (MOC) pricing. This is because MOC pricing cannot be associated with a consumer surplus increase (Carter &Milon, 1992). Moreover, their cost structures should be distinguished. To ensure profitability under short-run costs, the fixed allocation rate must be reduced. Short-run AC pricing must respond to market needs to achieve the goals of consumer purchases and profit maximization (OIG, 2013). The goal of the MC pricing strategy is to achieve the lowest sellable price of a product, enabling businesses to survive during times of economic difficulty. Because sunk fixed costs are ignored, the MC pricing strategy enables businesses to theoretically operate without loss (Gramlich and Ray, 2015).

In a hybrid management environment with new and old equipment, businesses optimize their effectiveness in identification, measurement, and decision making to reduce their various losses. These losses include ineffectiveness, low equipment availability, and inconsistent quality. Technology can affect equipment functioning, but high OEE depends entirely on training and implementing (Irhirane et al., 2017).The essence of OEE, reliability, and maintainability is to establish system effectiveness. That means that a machine individually or as part of a subsystem or as a system must be operating as designed. If it happens however, to have an unscheduled downtime, this downtime must be at the very minimum. This is very important because as the unscheduled overtime increases, and production decreases(Stamatis, 2017). The capital-intensive manufacturing industry invests heavily in precision equipment. Continual investment and the production of different equipment types can be combined using a coherent procedure. The firstpriorityin operation is efficiency. Market orientation is used to respond to the supply and demand relationship of precision computation. Supply chain relationship management is developed to respond to OEE. According to total productivity management and lean maintenance, the space for potential efficiency improvement can be separated into spaces for addressing internal process loss and external market demands. For example, reducing the amount of idle equipment, having equipment maintenance periods, and increasing the efficiency of mold upload and download can all contribute to profit maximization(Starr et al., 2010).Using OEE, manufacturing performance can be managed and production equipment maintained to increase profitability. Specifically, OEE is determined in five steps: (1) production equipment check, (2) qualified operator check, (3) production process allocation and classification,

(4) total productivity management and lean maintenance implementation, and (5) calculation of the efficiency rate, availability, and quality (Hansen, 2002).OEE should reflect the work efficiency, equipment speed, and quality of goods and hence be an indicator of operational performance, indicator of equipment availability, and standardization of quality judgement. Additionally, OEE should fit meet various needs but be standardized across different industries. This is the optimized decision-making tool for manufacturing (Dal et al., 2000).To giving consideration to businesses' product quality and customer satisfaction, total quality management and quality function deployment (QFD) were developed in the United States and Japan, respectively. This prompted connection between engineering design, manufacturing, and customer service. The contributions being made by businesses are discovering the voices of customers, identifying the needs of related parties, and meeting those needs (Griffin and Hauser, 1991). Typically, the biggest reductions to utilization are due to set-ups and maintenance downtime. To reduce the impact of set-up times on machine throughput, you must measure and report the time spent on set-ups as a discrete measure for each machine. It can do the same for time spent on PMs. Data should be collected so that accounting can calculate the variance, positive and negative with the standard. Maximum efficiency is usually defined as the production of maximum satisfaction through investment in each product. In terms of education, the focus of efficiency is to reduce costs and improve learning outcomes (Sage &Burrello, 1994). Resource loading describes the condition of various resources required by the manufacturing process and personnel within a specific period. All businesses have limited resources, and production must be completed under this constraint, as must manufacturing scheduling. The work outcomes of manufacturing management must satisfy internal and external demands and the requirements of employees; additionally, dimensions such as quality, range, time, and cost must be balanced. Manufacturing planners and personnel must ensure that worksite satisfaction is high through resource allocation and resource leveling. It strongly recommends the use of the RTY (rolled throughput yield) as the much more accurate measure. Moreover, further reconcilement can be implemented to enable businesses to allocate resources more effectively. Resource leveling is also referred to as resource smoothing and balances all the resources required during manufacturing. The purpose of leveling manufacturing resources is to ensure that the resources required throughout manufacturing are relatively constant over time, thereby ensuring robustness in output on the basis of resource availability and manageability. Resource leveling heuristics is a type of network analysis method that determines scheduling by considering resource availability and manageability. When resource overauthorization or imbalance occurs, factors such as resource reconcilement and limitation can be considered; additionally, time extensions and communication flexibility can be used to conduct resource leveling and thereby provide the optimal manufacturing equipment and personnel utilization. Resource leveling methods include the float method and task division method. Time paths are usually longer than the original time path when resource leveling is applied (Gilbert, 2013).

III. Model Development

A mathematical model that improves the MC pricing is developed in this chapter. The model includes the following quality index, performance index, and equipment availability index. Quality criterion normally follow a rating range of three categories such as excellent (±1 sigma), good (±2 sigma) and loose (±3 sigma) as index as 0.68, 0.95 and 0.99. This emphasizes the importance of a quality index's correspondence with the MC. Moreover, the personnel discipline performance is poor, its effect on the MC pricing is stronger. Finally, when equipment utilization index is essential to product effectiveness, understanding the adequate use condition of equipment is crucial. With changes in workmanship dynamics, quality function deployment responds differently to the quality criterion index, personnel performance index, and equipment effectiveness index. Similarly, the quality index changes according to the learning curve, and consumption is the loose, good, and excellent in the first, medium-term, and third stages, respectively; similarly, the personnel performance index may be excellent, good, and loose in the first , medium-term, and third stages. respectively. The equipment effectiveness index is the excellent, good, good in the first, second, and third stages. Detailed information is shown in Table 2.

Table 2 Beta coefficient model

	parameter	*Experimental level*		
		I	II	III
s_1	q_{1j}	Loose	Good	Excellent
	p_{1j}	p_{11}	p_{12}	p_{13}
	a_{1j}	a_{11}	a_{12}	a_{13}

	parameter	Experimental level		
		I	II	III
s_2	q_{2j}	Excellent	Good	Loose
	p_{2j}	p_{21}	p_{22}	p_{23}
	a_{2j}	a_{21}	a_{22}	a_{23}

parameter		Experimental level		
		I	II	III
s_3	q_{3j}	Excellent	Good	Good
	p_{3j}	p_{31}	p_{32}	p_{33}
	a_{3j}	a_{31}	a_{32}	a_{33}

Whereq_{ij} is the quality index of quality *i* at stage *j*; $p_{ij}$is the performance index of employee *i* at stage *j*; and a_{ij} is the performance index of equipment *i* at stage *j*. Production orders are separated into three batches—s1, s2, and s3—and each batch was separated into stages 1–3. The index of product OEE importance is determined using the quality indexes, operational performance indexes, and equipment availability indexes. The mutual contagion model of the three crucial OEE indexes corresponds to the ultimate key index of beta coefficient. The quotient of beta coefficient derives from OEE=P*A*Q, when OEE=1, then leveling at OEE=β(P*A*Q), and then a substitution formula asβ=OEE/P*A*Q.

The objective of this study is to construct a mathematical model that includes all the aforementioned factors. A model for calculating the optimal beta coefficient can be constructed as

$$Max\ O = \sum_{j=1}\sum_{j=1}\sum qj\, p_{ij}$$

$$S.T.\ \beta_i = O \Big/ \sum_{j=1} O_{ij} \quad i = 1 \ldots m$$

$$\sum_{i=1}^{m} \beta_i \le w$$

$$aij = f\,(p_{ij})$$

$$0 \le p_{ij} \le z_i$$

where $O$is the OEE;
$O = 1$;
$\beta_i$isthe corresponding index of SMC;and $w$is upper limit of the corresponding index of SMC.The zi is upper limit of performance indexes.

IV. Case Discussion

The effectiveness of the model proposed in this study is illustrated using a case study. The hypothetical production order of SMC can be separated into three stages. Additionally, a production order has three batches (s1–s3). The indexes and changing index for each production order in the three stages are displayed in Table 3.

Table 3 Beta coefficient model for the case study

parameter		*Experimental level*		
		I	II	III
s_1	q_{1j}	Loose(0.99)	Good (0.95)	Excellent (0.75)
	p_{1j}	p_{11}	p_{12}	p_{13}
	a_{1j}	a_{11}	a_{12}	a_{13}

parameter		Experimental level		
		I	II	III
s_2	q_{2j}	Excellent (0.68)	Good (0.95)	Loose(0.99)
	p_{2j}	p_{21}	p_{22}	p_{23}
	a_{2j}	a_{21}	a_{22}	a_{23}

parameter		Experimental level		
		I	II	III
s_3	q_{3j}	Excellent (0.68)	Good (0.95)	Good (0.95)
	p_{3j}	p_{31}	p_{32}	p_{33}
	a_{3j}	a_{31}	a_{32}	a_{33}

The OEE of performance indexes for the three stages of a production order is calculated, as shown in Table 3. The performance and validity of the OEE changes according to the production order batch. In production order s1,the OEE is relatively high, lower, and even lowerin the early, medium-term, and late stages, respectively. In production order s2,the OEE is relatively low, relatively high, and even higher in the early, medium-term, and late stages, respectively. Finally, in production order s3, the OEEis low in the early stage and equally high in the medium-term and late stages. Numerical analysis of the OEE shows that the performance of e1 in the early stageis q11 = 0.99, medium-term stage is q12 = 0.95, and late stage is q13 = 0.75. The corresponding values fors2 are q21 = 0.68, q22 = 0.95, and q23 = 0.99 and fors3 areq31 = 0.68, q32 = 0.95, and q33 = 0.95. Following analysis of the aggregative index in Table 3, the parameters were set as$O = 1$, $w = 4.5$, $a_{ij} = p_{ij}^2 - p_{ij}$ + index, $q_{11} = 0.99$, $q_{12} = 0.95$, $q_{13} = 0.75$, $q_{21} = 0.68$, $q_{22} = 0.95$, $q_{23} = 0.99$,$q_{31} = 0.68$, $q_{32} = 0.95$, $q_{33} = 0.95$, obtaining the following overall model:

Max $O/(O_{11}+O_{12}+O_{13}) + O/(O_{21}+O_{22}+O_{23}) + O/(O_{31}+O_{32}+O_{33})$

S.T. $\beta_1 = O/(O_{11}+O_{12}+O_{13})$

$\beta_2 = O/(O_{21}+O_{22}+O_{23})$

$\beta_3 = O/(O_{31}+O_{32}+O_{33})$

$\beta_1 + \beta_2 + \beta_3 <= 4.5$

q11 = 0.99;
q12 = 0.95;
q13 = 0.75;
q21 = 0.68;
q22 = 0.95;
q23 = 0.99;
q31 = 0.68;
q32 = 0.95;
q33 = 0.95;
0.9<p11<= 0.99;
0.85<p12 <= 0.95;
0.8<p13 <= 0.9;
0.8<p21 <= 0.9;
0.8<p22 <= 0.95;
0.9<p23 <= 0.99;
0.8<p31 <= 0.9;
0.85<p32 <= 0.95;
0.85<p33 <= 0.95;
$a_{11} = p_{11\wedge 2 -} p_{11} + 0.5$;
$a_{12} = p_{12\wedge 2 -} p_{12} + 0.45$;
$a_{13} = p_{13\wedge 2 -} p_{13} + 0.4$;
$a_{21} = p_{21\wedge 2 -} p_{21} + 0.4$;
$a_{22} = p_{22\wedge 2 -} p_{22} + 0.45$;
$a_{23} = p_{23\wedge 2 -} p_{23} + 0.5$;
$a_{31} = p_{31\wedge 2 -} p_{31} + 0.4$;
$a_{32} = p_{32\wedge 2 -} p_{32} + 0.4$;
$a_{33} = p_{33\wedge 2 -} p_{33} + 0.4$;
O11 = q11 * p11 * a11;
O12 = q12 * p12 * a12;
O13 = q13 * p13 * a13;
O21 = q21 * p21 * a21;
O22 = q22 * p22 * a22;
O23 = q23 * p23 * a23;
O31 = q31 * p31 * a31;
O32 = q32 * p32 * a32;
O33 = q33 * p33 * a33;
End

By using Lingo to seek solutions, the maximum beta coefficient of 4.45 is obtained.The quality index, performance index, effective index,and overall index at each stage are listed in Table 4. Because the beta coefficient (β) reflects the OEE changing index, these values indicate that activity-based throughput yieldof the first, second, and third batches were 1.30, 1.40, and 1.75, respectively. These final yields correspond to the MC costs in real operations.

Table 4 Beta coefficient model for case study

parameter		*Experimental level*		
		I	II	III
s_1	q_{1j}	Loose(0.99)	Good (0.95)	Excellent (0.75)
	p_{1j}	0.9	0.85	0.8
	a_{1j}	0.41	0.32	0.24
O1j		0.37	0.26	0.14
β 1			1.30	

parameter		Experimental level		
		I	II	III
s_2	q_{2j}	Excellent (0.68)	Good (0.95)	Loose (0.99)
	p_{2j}	0.8	0.8	0.9
	a_{2j}	0.24	0.29	0.41
O2j		0.13	0.22	0.37
β 2			1.40	

parameter		Experimental level		
		I	II	III
s_3	q_{3j}	Excellent (0.68)	Good (0.95)	Good (0.95)
	p_{3j}	0.8	0.85	0.85
	a_{3j}	0.24	0.27	0.27
O3j		0.13	0.22	0.22
β 3			1.75	

Following explanation of production order separation batches from a practical perspective, the OEE of each batch indicates the indexes displayed in Fig. 2. O1j is 0.37, 0.26 and 0.14,and the cost factor of β1 = 1.30, higher than the set value of MC cost underOEE= 1. O2j is 0.13, 0.22, and 0.37, and the unit actual factor is β2 = 1.40, higher than the set value of MC cost underOEE= 1. O_{3j} is 0.13, 0.22, and 0.22, and the unit actual factor is β3 = 1.75, higher than the set value of MC costunderOEE = 1, as illustrated in Table 5. In practice, the cost pool is reconciled with thedynamics of manufacturing indexes, and a higher beta coefficient corresponds and monitors to a higher cost and greater deviation fromfixed MC pricing.

Fig. 2 β vs. MC

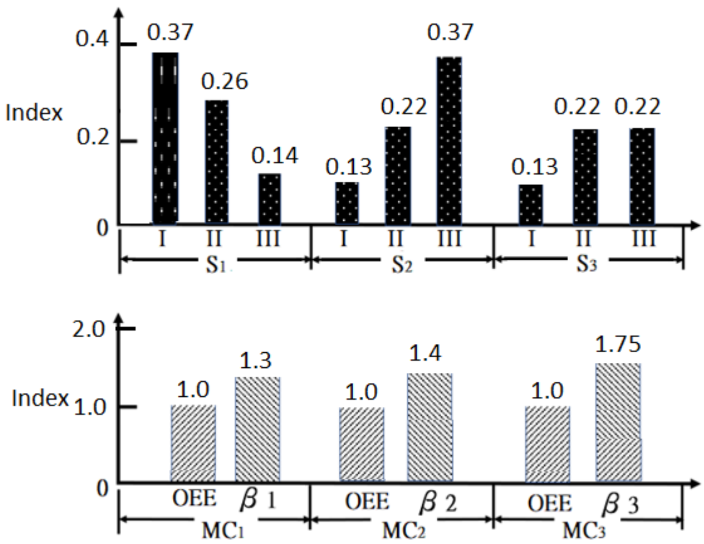

Table 5 Correspondence among β, MC and OEE

Item / Stage	I	II	III	β	MC	βMC
S1	0.37	0.26	0.14	1.3	\$10	\$13
S2	0.13	0.22	0.37	1.4	\$10	\$14
S3	0.13	0.22	0.22	1.75	\$10	\$17.5
Note	--	--	--	--	OEE=1	Actual cost

V. Conclusion

Although firms facing perfect competition can achieve balance, they cannot adjust production size and may experience losses to achieve short-term OEE balance when the production capacity is constant. When the scale is small and diversity of production is high, the production capacity of business equipment is not adequately used. The beta coefficient goes down due toincreasing at OEE as three indexes of quality, performance and availability. At this stage, the rate of production increase exceeds the rate of cost increase. Meanwhilein a perfectly competitive market, the fundamental reason for increasing the MC is the diminishing marginal product. The short-term balance condition for firms is MR = MC. Conditions of long-term balance in firms in a perfectly competitive market exist within short time periods. Consequently, the MC decreases as production capacity increases.

The OEE should be improved to enhance the quality index, performance index, and availability index. These three indexes reflect the losses incurred by defective goods, human and machine idle time, and waiting time. The MCofOEE corresponds to the beta coefficient, and the objective is to determine increases and decreases in the beta coefficient for different departments and products in a timely manner. This prevents arbitrary allocation of illogical costs in the Q, P, and A. Simple calculation can apply for any metric definition for which there is varying industry accepted formulas, thereby obtaining profitable MC pricing that correspond to the beta coefficient. Accordingly, business profit can be optimized.

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